

Nuclear Thermal Propulsion for Human Transportation Systems

Part 2: NTP Infrastructure and Technology Recapture

Presented to

**NASA Strategic Roadmapping Federal Advisory Committee for
Nuclear Systems
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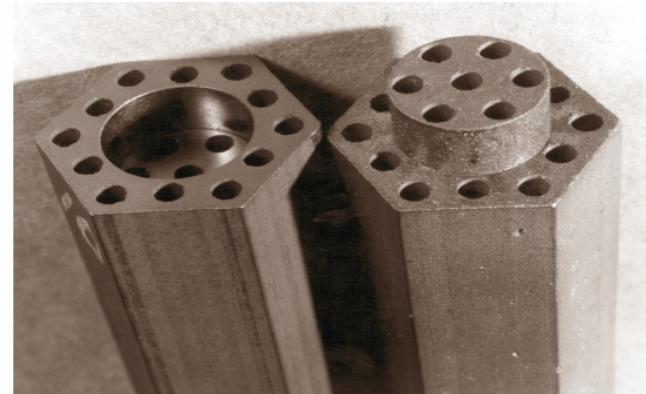
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Office of Nuclear Energy, Science and Technology

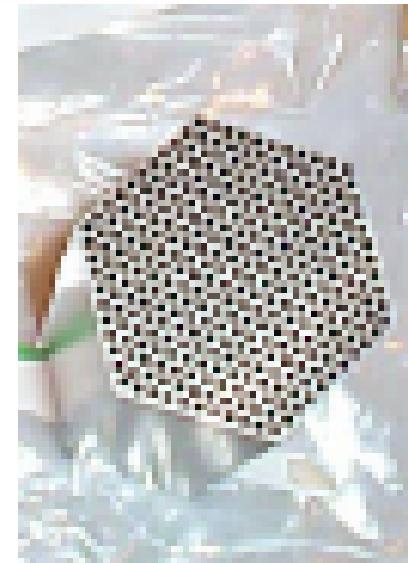
U.S. Department of Energy

Basic Fuel Types

- Carbide/Graphite-based
 - Coated particles imbedded in graphite with coating
 - UC₂ particles with pyrolytic graphite coatings
 - Composite (U,Zr)C
 - Pure carbides
 - Binary or ternary
- Cermets
 - Ceramic fuel (UO₂ or UN) imbedded in high temperature metallic matrix (W, Mo, or Re)



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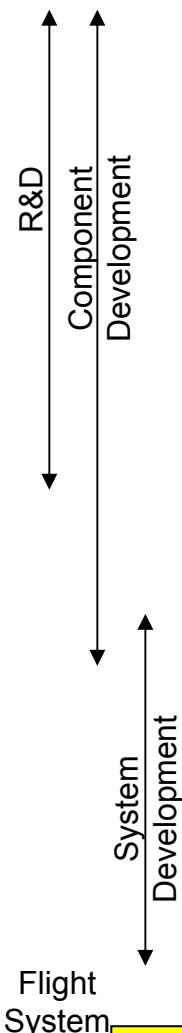
NTP Infrastructure Requirements Are Dependent on Level of Activities

- R&D
 - Fuels and Materials/Long-lead Technologies
- Component-Level
 - Prototypic Fuel Element and Components
- System-Level
 - Full Scale Reactor/Engine Development
- Flight System

Example: NTP Fuels and Materials R&D Activities

- Specimen fabrication
- Test specimens
 - Unirradiated
 - Flowing hot hydrogen transient testing (clean facility)
 - Material properties testing (physical, chemical)
 - Interaction questions (corrosion, erosion)
 - Ex-core testing of specimens irradiated to prototypic burnup
 - Flowing hot hydrogen transient testing (radiation facility)
 - Material properties testing (physical, chemical)
 - Interaction questions (corrosion, erosion)
 - Vacuum test at temperature

Potential NTP Facilities and Status



Facilities	Status
Fuel Fabrication Facilities	1
Unirradiated Fuel Materials Test Facilities	1
Unirradiated Materials Test Facilities	3
Hot-hydrogen Flow Test Facilities	1
Fuel Irradiation Test Facilities	2
Material Irradiation Test Facilities	2
Remote Inspection/Post-irradiation Examination Facilities	1
Fuel Element Loops in Existing Reactors	1
Low-power Critical Facilities	1
Component Test Facilities without Hot-hydrogen or Irradiation Environments	3
Component Safety Test Facilities	3
Prototypic Fuel Element Test Reactor	0
Control System Test Facilities	3
Training and Simulator Test Facilities	0
Reactor Test Cell	0
System-level Safety Test Facilities	0
Engine Integration Test Facility	2
Engine Ground Test Cell	0
Flight Test Facilities	0

0 = No current facilities

2 = Exist but may need eventual modification or equipment purchases

1 = Exist but need modifications or equipment purchases

3 = Exist and need no modifications

Recapture from Past NTP Programs

- Design
 - Rover/NERVA, 710 Reactor, and other program design documentation, including shield work
- Fuel elements
 - Rover/NERVA technology
 - 710 Reactor and Argonne National Laboratory cermet fuel technology
 - Coating technology
- Materials
 - Core support, lower plenum, nozzle
 - Coating technology

Strategic Considerations

- Conduct R&D early
- Decide on major infrastructure elements after additional evaluations of capability need and related assessments (environmental, cost, etc.) are completed.
- Assess value/cost of preserving potentially important infrastructure items until programmatic need and funding are determined, e.g.
 - TAN Hot Shop/Warm Shop (imminent risk of losing capability)
 - TAN Contained Test Facility (imminent risk of losing capability)
 - Additional infrastructure elements (dyes, extrusion and furnace capability, other facilities)
- Consider best use of fuel in storage
- Explore synergies with other programs, e.g.
 - Accommodation in design of Advance Test Reactor gas loop for possible NTP applications
 - High temperature gas reactor technology work
- Human infrastructure-maximize contributions from remaining experts, train a new cadre that can support NASA and DOE
- Organizational structure between NASA and DOE for R&D and possible follow-on development efforts



NTP Infrastructure (Backup Material)

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Additional Infrastructure Considerations

- Irradiated fuel vacuum test capability (for in-space environment between engine runs)
- Reactor and/or engine maintenance assembly and disassembly
- Packaging, transportation, and storage infrastructure
- Irradiated fuels and materials disposition infrastructure
- Hot hydrogen nozzle test facility
- Launch site facilities

Existing Facilities

- Extensive listing of candidate facilities previously developed
 - Needs to be updated to address changes
- Sample listing of some existing facilities:
 - Fuel/material specimen development/fabrication laboratories (DOE labs)
 - Fuel element development and fabrication (Commercial)
 - Advanced Test Reactor, High Flux Isotope Reactor (Irradiation Facilities)
 - Hot cells for post irradiation examination (DOE labs)
 - Criticality Facility (Zero Power Physics Reactor)
 - Nevada Test Site
 - Device Assembly Facility (engine assembly)
 - Bore Holes (engine testing)
 - Test Area North at Idaho
 - Hot Shop (Assembly/disassembly)
 - Contained Test Facility (small reactor/engine testing)
 - Shield fabrication facility (commercial or Y-12 if unique material)